VEGETATIONAL SUCCESSION ON COASTAL RANGELAND OF POINT REYES PENINSULA

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Most of Point Reyes Peninsula in Marin County, California, has recently become administered by the National Park Service to provide both public recreation and the continuance of some private livestock operations. Previous clearing of the land for pasture and continued cattle grazing have forced the coastal scrub and coastal prairie plant communities toward low seral stages of plant succession. Future recreational uses may eliminate cattle grazing and allow succession to advance toward a climax type. Our objective is to infer the composition of the early seres on abandoned rangeland by documenting the relative cover of the major plant species on three neighboring fields—one heavily grazed, one moderately grazed, and one protected from cattle grazing for the previous six years. The study plots have been permanently demarcated so comparative sampling in future years can document the presence of the climax type.

The Study Area

Point Reyes receives most of its precipitation during the late fall, winter, and spring. This Mediterranean type rainfall pattern, typical of much of California, is modified by the moisture condensed from summer fog. Climatic data for the Point Reyes Lighthouse are incomplete for the past 31 years; but the records correlate with those of San Francisco, 56 km to the southeast. San Francisco received 269 mm rainfall between July, 1971, and June, 1972. This was an unusually dry year. A 63 year average for the Point Reyes Lighthouse is 483 mm. However, the vegetational composition is predominately perennial and is not dramatically sensitive to annual variations in rainfall as confirmed by preliminary sampling in the previous normal year. The 60 year mean January temperature at the Lighthouse in 1941 was 9.8°C; mean July temperature was 12.1°C.

For nearly a century, Point Reyes Peninsula has been the site of grazing by dairy cattle (Mason, 1970). Visual reconnaissance of the topography and vegetative pattern, along with information gleaned from local ranchers, indicates that none of the area on the study plots had been cleared and planted for pasture, hay, artichokes, or peas as in some nearby fields. However, fires may have been set years ago in attempts to replace scrub with grassland. Early photographs by American Telephone and Telegraph Company of the heavily grazed field indicate that, approximately 45 years ago, it had clumps of perennial grass and scrub

similar to those presently found on the moderately grazed and protected fields.

The three study plots are within a radius of 0.8 km on level ground of the coastal plain immediately east of the dunes behind Point Reyes Beach (fig. 1). The plots vary in elevation from 24 m to 33 m on mesic soils of the Sheridan-Baywood association (Soil Conservation Service, 1967). This soil is deep, well-drained, sandy, and moderately acidic.

Plot I is a 37 × 92 m rectangle of heavily grazed grassland at the southern end of the enclosed field that surrounds the American Telephone and Telegraph radio station. Much of this 212 hectare field is covered by sand dunes and only 116 hectares are suitable for grazing (Jones, 1969). The heavy grazing results from a stocking rate of 1.16 foragable hectares per cow.

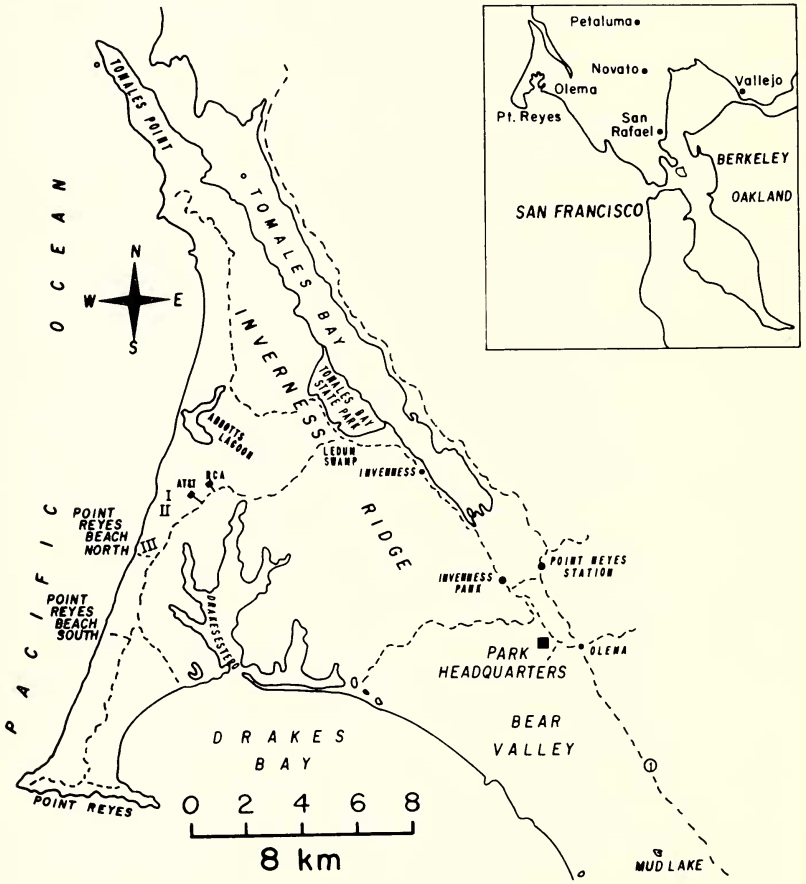

FIG. 1. Map of Point Reyes Peninsula, California, showing location of study area and study plots (I, II, and III).

Plot II is a 46 × 92 m "island" of mesic vegetation in the moderately grazed field. It is adjacent to plot I at the north end of the field just south of the A. T. & T. property. The grazing on this land has been moderate since at least 1949 at 2.63 hectares per cow.

Plot III is 18 × 82 m. It is the only substantial mesic patch in the ungrazed field. It is located immediately south of the moderately grazed field and had been exclosed for at least six growing seasons, since the National Park Service completed the northern access road to Point Reyes Beach in January, 1967.

Methods

To facilitate comparisons between plots, we avoided both the xeric soils that supported sparse and stunted vegetation, and the hydric swales characterized by Howell (1970, p. 15) as supporting "rank growths of grasses, sedges, and rushes . . .". We restricted the plots to the mesic soil of "the drier mesa-like flats that are covered with low annuals and perennials".

To further substantiate the similarity of the plots, soil samples were collected by taking a core of the top 15 cm in each plot. They were weighed after air drying and root and litter material was separated by passing the soil through a 2 mm sieve. This organic fraction was expressed as a percentage of the initial soil weight. The moisture content of the recombined air dry soil was determined by difference after drying at 105°C for 48 hours. Soil pH, soil conductivity, and concentrations of water-soluble potassium, sodium, calcium, and magnesium were determined by methods described in Black et al. (1965). Although soils of the three plots differed somewhat (Table 1), the differences are not considered ecologically significant. For example, conductivities of 1.31, 1.47, and 2.17 millimhos all produce "mostly negligible" salinity effects according to the U. S. D. A. (Richards, 1954).

Vegetational sampling was done with the point-plot method (Heady, 1957). A frame holding ten vertical pins, as described by Heady and Rader (1958) was placed every 2.75 or 3.05 m along parallel transects 4.58 to 12.2 m apart to cover the varying sizes of the restricted plots.

Table 1. Summary of Soil Analysis.

Test	Plots		
	I	II	III
Moisture loss of air dry soil when heated to 105°C	1.23%	1.61%	1.54%
Amount of organic matter (roots and litter)	0.52%	3.74%	1.42%
Water soluble			
K	0.184	0.272	0.522
Na	1.52	2.14	5.64
Ca	0.935	1.42	1.89
Mg	1.09	1.60	2.93
(expressed in milliequivalents/100 gm oven-dry soil)			
Conductivity (millimhos)	1.31	1.47	2.17

Each pin was pushed downward and the first species hit along with the height above the ground of the pin's contact were recorded. The total number of hits on a species, calculated as a percentage of the total number of hits on all species, determined the relative cover value of that species. Any hit on unattached vegetation was defined as litter.

Plot III was sampled during the last week of April, 1972, and plots I and II were sampled together during a month beginning the last week of May, 1972. Variation of relative cover due to growth within the month interval between samplings was small because of the predominantly perennial type vegetation. The only important species noted to become senescent at the later sampling was *Ranunculus californicus*.

Approximately 1,400, 1,500, and 1,550 points were sampled on Plots I, II, and III, respectively. To determine the variability of the sampling technique, relative cover values on all plots were calculated at 100-point intervals for species whose final values were greater than 4 percent. For intervals above 1,000 points, the average of the deviations for all such species was 12 percent of the final percentages, and above 1,300 points, the average was 6 percent.

Chi-square values were used to determine significant differences of relative cover between plots. They were calculated with a standard two by-two contingency table and corresponding equation as given by Knight (1965). Only species of 0.5 percent or greater relative cover, before being rounded to the nearest 0.5 percent, are discussed below. Many species of lower relative cover values were present, but chi-square values determined that a relative cover below 0.5 percent was not significantly different from 0.0 percent. Voucher specimens, identified according to Munz (1959, 1968), have been deposited in the herbarium of Point Reyes National Seashore, Point Reyes, California 94956.

Results and Discussion

The average heights per pin for all pins hitting vegetation on plots I, II, and III were 5.0, 11.0, and 16.5 cm, respectively. These average heights substantiate well the different visual appearances of the three plots. The gradation of heights is a function of both differential grazing pressure by cattle and species composition.

Table 2 lists the relative cover values for the species on each plot in order of decreasing values on plot III. Successional changes are inferred from significant differences between plots that represent different seres.

The heavily grazed field, plot I, is dominated by species adapted to withstand grazing. *Eryngium armatum* is a low, prostrate forb with stiff, prickly spines. *Baccharis pilularis* ssp. *pilularis* is a shrub that is considered unpalatable to livestock (McBride and Heady, 1968), although it is browsed in heavily grazed pastures on neighboring dairy ranches. *Danthonia californica,* a native perennial grass, has protected cleistogamous florets and a low spreading form. The exotic annuals, *Aira*

Table 2. Relative Cover on Coastal Rangeland Plots Subjected to Differential Grazing Pressure. Successional changes are inferred from significant differences between plots ($P < 0.05$) indicated by asterisks between adjacent columns. Values are percentages of total vegetative hits per plot. "hit" indicates the species was hit less than 0.5 percent; — indicates no hits; NP = Native Perennial; NBi = Native Biennial; IP = Introduced Perennial; IA = Introduced Annual; # = indicator species of coastal prairie; † = indicator species of coastal scrub.

Taxon	Origin and seasonality	Relative cover on plots (%)				
		I		II		III
#*Deschampsia caespitosa* ssp. *holciformis*	NP	3.5	*	15.5	*	23.0
†*Baccharis pilularis* ssp. *pilularis*	NP	13.5	*	18.0	*	12.0
Bromus carinatus	NBi	2.0		2.5	*	9.5
Rumex Acetosella	IP	3.5		2.0	*	6.0
#*Pteridium aquilinum* var. *pubescens*	NP	3.0	*	4.0		4.5
Hordeum brachyantherum	NP	0.5	*	5.0		3.5
Lolium perenne	IP	4.5	*	6.5	*	3.0
Achillea borealis ssp. *californica*	NP	2.5		2.5		3.0
Plantago lanceolata	IP	3.0	*	9.0	*	3.0
#*Iris Douglasiana*	NP	hit	*	1.5		3.0
#*Ranunculus californicus*	NP	—		—	*	3.0
#*Holcus lanatus*	IP	—	*	2.0		2.5
Armeria maritima	NP	—		—	*	2.5
Elymus glaucus	NP	1.0		1.0	*	2.0
Rhus diversiloba	NP	—		—	*	2.0
#*Sisyrinchium bellum*	NP	1.5		1.0		2.0
†*Rubus vitifolius*	NP	hit		hit	*	1.5
Cirsium quercetorum	NP	2.0	*	0.5	*	1.5
Stachys rigidus ssp. *quercetorum*	NP	hit		hit	*	1.0
#*Danthonia californica*	NP	7.0	*	3.5	*	1.0
Festuca dertonensis	IA	5.5		4.5	*	1.0
Hypochoeris radicata	IP	5.5		4.5	*	1.0
Chlorogalum pomeridianum	NP	—		—	*	1.0
Grindelia stricta ssp. *venulosa*	NP	—		—	*	0.5
Bromus mollis	IA	hit	*	1.0		0.5
Perideridia Kelloggii	NP	—		hit	*	0.5
#*Carex tumulicola*	NP	1.0		1.0		0.5
Vicia americana var. *linearis*	NP	—		—	*	0.5
Phleum alpinum	NP	hit		—	*	0.5
†#*Lupinus variicolor*	NP	1.0	*	3.0	*	hit
Juncus Lesueurii	NP	0.5		0.5		hit
Juncus phaeocephalus	NP	4.0	*	1.5	*	hit
Aira caryophyllea	IA	8.0	*	4.5	*	hit
Briza minor	IA	0.5		hit		hit
Galium Aparine	IA	—		0.5		hit
Horkelia marinensis	NP	1.0		hit		hit
Cardionema ramossissimum	NP	2.0	*	0.5	*	—
Eryngium armatum	NP	17.0	*	1.0	*	—
Hypochoeris glabra	IA	1.0		hit		—
Agrostis spp.	NP	1.0	*	—		—
Panicum pacificum	NP	1.0	*	—		—

caryophyllea and *Festuca dertonensis,* are small grasses and are the first to set seed. Thus, they have a higher probability of leaving seeds for the following year than do taller, slower growing perennials. Heavy grazing also results in more open ground where annual species can successfully germinate.

Indicative of the moderate grazing on plot II are the high relative covers of the palatable species *Plantago lanceolata* and *Lolium perenne.* This grazing pressure permitted *Baccharis pilularis* ssp. *pilularis,* a low shrub, to reach its highest relative cover and co-dominate plot II with *Deschampsia caespitosa* ssp. *holciformis,* a native bunch grass.

The mesic area of the protected field, plot III, can be described as predominantly a perennial grassland with clumps of low scrub. Nine species present are indicator species for the coastal prairie plant community (Munz, 1959) and three are indicator species for the northern coastal scrub community (Table 2), which is described as ". . . often with extensive areas of grass (*Danthonia californica, Deschampsia caespitosa* ssp. *holciformis, Calamagrostis nutkaensis, Holcus lanatus,* etc.) . . ."

The total relative covers of perennial and biennial species on plots I, II, and III were 81.5, 87.5, and 94.0 percent, respectively. Chi-square values determined significant differences between them ($P < 0.5$). This substantiates the following:

1) Climatic and edaphic factors influencing the study areas favor perennial plants. Summer fog extends the wet season and allows perennial species to thrive (Davy, 1902) and to dominate the xeric-adapted annuals. Inferiority of annuals in this environment is emphasized by the relative rarity of annual wild oats (*Avena* spp.) on the peninsula, although they were once cultivated there for hay, have spread successfully throughout much of California (Robbins et al, 1951), and are abundant directly inland on the eastern side of Tomales Bay.

2) Grazing pressure has created a disclimax on plots I and II as compared with the protected community of plot III. Although some native California plants are believed to contain volatile chemicals that deter native ungulate grazing (Longhurst et al., 1968), they remain palatable to domestic livestock. Thus, they are subject to heavy use, which reduces plant vigor and removes a critical amount of mulch. This causes an increase in species characteristic of lower seral stages (Heady, 1966), i.e., the increase of exotic annual species and a decrease in the native (predominantly perennial) vegetation on the heavily and moderately grazed plots (Table 3).

3) The removal of cattle from plot III has caused a successional change toward a climax community in the last six growing seasons. It is now composed of 78.5 percent native species compared with 65.0 percent on the heavily grazed plot. However, it may never recover pristine climax conditions. The perennials *Rumex Acetosella, Lolium perenne,*

Table 3. Total Relative Covers on Plots. Asterisks between adjacent columns indicate significant differences ($P < 0.05$) between plots.

	Relative cover on plots (%)				
	I		II		III
Perennial and biennial species	81.5	*	87.5	*	94.0
Annual species	15.0		10.5	*	1.5
Native species	65.0	*	63.5	*	78.5
Introduced species	31.5	*	34.5	*	17.0
Species less than 0.5%	3.5		2.0		4.5

Plantago lanceolata, Holcus lanatus, and *Hypochoeris radicata,* with total relative cover of 15.5 percent, are exotic species that are so well adapted to the environment that they can be expected to be retained as a part of the climax community (H. F. Heady, personal communication). Also, tule elk, which once foraged on the peninsula and were seen with "a thousand elk in one herd" (Mason, 1970, p. 19), may have had an effect on the composition of the vegetation. And the frequency of fire may have changed. Fire may have periodically swept through the area modifying the grassland to fire-resistant species, and reducing the scrubland to grassland (Wells, 1962).

Only surveys repeated in future years will determine whether climatic, edaphic, and zootic climaxes are currently present on the field protected from cattle grazing.

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NOTES AND NEWS

A Range and Elevation Extension for Ipomopsis polycladon.—On 5 May 1973 I discovered a small population of *Ipomopsis polycladon* (Torr.) V. Grant on southwest-facing slopes of gravelly soil at about 1140 m in Upper Johnson Valley, T6N, R3E, Sec. 25, San Bernardino County, California (voucher: UCR 13396). *Ipomopsis polycladon* has been described as rare in California (Munz, P.A., *Manual of Southern California botany,* The Lancaster Press, Inc., Lancaster, Pa., 1935) in the eastern Mohave Desert, notably near Needles and from the Argus, Ivanpah, and Kingston ranges. A review of the literature and of the few specimens at JEPS, RSA, and UC revealed two unpublished elevation and two unpublished range extensions. The elevation extensions derive from a specimen collected by P. A. Munz at 2044 m near Bridgeport, Mono County, and one by V. Duran at 2135 m in the White Mountains (UC 809749 and 908125), both above the 1610 m maximum given by Munz (*A California flora,* University of California Press, Berkeley, 1959). Range extensions include a find by G. T. Robbins et al. near Hector Mine, 3 km south of Pisgah (JEPS 8002), one collection, 6 km northwest of Adelanto, by J. and L. Roos, near Red Raven Mine (RSA 92547), and now the Upper Johnson Valley collection, all in western San Bernardino County. The range extensions are about 160 km south from the Argus and Kingston ranges, and from about 175 to 275 km west from the eastern desert localities at the Ivanpah range and Needles. The Johnson Valley find may be important because California specimens number less than thirty, none have been collected since 1958, and because a power generating station is planned on the site of collection.—David H. Eslinger, Dry Lands Research Institute, University of California, Riverside 92502.